From: Rob Gailey [mailto:rob@rmgailey.com]
Sent: Thursday, September 28, 2006 11:02 PM
To: Svetich, Ralph
Subject: Comments on Levee Fragility Initial Technical Framework

Mr. Svetich,

I offer the following comments on the Delta Risk Management Strategy Initial Technical Framework Paper regarding levee fragility. These comments are based on both my overall experience as a quantitative hydrogeologist and my specific experience evaluating groundwater conditions associated with a levee failure on the Feather River.

Representation of Seepage

The ITF paper indicates that seepage through and under levees will be evaluated by two-dimensional cross-sectional modeling. While this approach might be sufficient for seepage through the levees themselves, it is not adequate for considering seepage under levees. Groundwater flow modeling should be performed in three dimensions because consideration of the horizontal dimension parallel to the levee axis is essential for evaluating the locations where, and the extent to which, flow fields distort and gradients/flows increase. Examples of conditions that could threaten levee stability and must be evaluated in three dimensions include:

- Macroscopic heterogeneities in the saturated porous media such as buried channels can create localized areas of higher flows. If such subsurface features are known to exist near a levee, they should be included in the analysis. This would require varying groundwater properties in the horizontal dimension parallel to the levee axis (the third dimension).
- Bends and corners in levee networks can concentrate pressures and increase gradients. Accurate representation of any levee system that surrounds a delta island requires consideration of both horizontal dimensions in addition to the vertical dimension.
- Breaks in the low hydraulic conductivity material on the flood side of the levee (i.e., pits or areas of scour) can increase flow under levees. Because groundwater flow from the break is divergent, correctly simulating the strength of this water source requires both horizontal dimensions as well as the vertical dimension.
- Consideration of appropriate locations and numbers of pressure relief structures on the dry side of the levee entails simulating convergent flow. Again, this would require three-dimensional modeling. This point is a very important point since pressure relief may be an economical means of managing certain risks of levee failure.

There are many three-dimensional groundwater flow models available. Consistent with the reference to SEEP/w in the ITF paper, the U.S. Geological Survey SUTRA code can simulate saturated and unsaturated flow in three dimensions using finite elements.

Estimation of Groundwater Model Parameters and Uncertainties

The ITF paper indicates that model parameter values and uncertainties will be determined based on statistical analysis of available data and expert interpretation. With respect to the groundwater modeling, a potentially more valuable approach might be to perform model calibration through nonlinear regression. The benefits of this approach are: 1) the repetitive work associated with calibrating the models is automated and 2) uncertainties are provided for the model parameter values estimated through regression. The model parameter uncertainties, provided in the form of a covariance matrix, can then be easily processed to yield model prediction uncertainties that would feed into the risk analysis. Many nonlinear regression routines exist and some are tailored to performing model calibration (i.e., PEST and UCODE).

Thank you for considering my comments and good luck with the project.

Robert M. Gailey, P.G., C.HG.
Consulting Hydrogeologist
http://www.rmgailey.com